A Multidisciplinary Approach to the Profiling and Interpretation of Fitness Testing Data: A Case Study Example

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Running Title: Multidisciplinary Approach to the Interpretation of Testing Data

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ABSTRACT

Fitness testing is commonly used to assess athletes' strengths and weaknesses. However, limitations exist including lack of position-specific comparative data, and little consideration for athletes' or coaches' needs. This article proposes a collaborative method for interpreting fitness testing data to address the practical limitations identified above. Data obtained from three male professional academy rugby league players (age 17.7 ± 0.6 years; height 180.1 ± 6.7 cm; body mass 88.8 ± 4.6 kg) were used for the purpose of this article. Following the fitness testing battery, in collaboration with each athlete, three professional coaches ranked the relative importance of each test (1 = least important; 7 = most important) for each player considering playing position, stage of physical and technical / tactical development, and future goals. Data were presented as absolute values, Z-scores and modified (benchmark; mean + 2 *SD*s) Z-scores in comparison to previously published data. The different approaches of data presentation identified different goals for each athlete. This article provides a novel approach for presenting and interpreting fitness testing data, considering athlete and coach needs. When profiling athletes, it is proposed that multiplying a modified Z-score by a factor based on relative importance of each characteristic may prove a useful tool for practitioners. In practice this process allows athletes and coaches to specifically focus on individual weaknesses, which are identified as being important for an athlete's particular role in their sport or their stage of development.

Key Words: Rugby, Strength, Speed, Athletic Development

INTRODUCTION

Fitness testing of athletes is common practice within strength and conditioning. Strength and conditioning coaches typically implement a testing battery to determine the characteristics of an athlete (6, 7, 26), provide objective data during talent identification and development (20, 22, 23), evaluate the effectiveness of training (25) or nutritional interventions (10), and develop/evaluate training programs based on athletes' weaknesses (11, 17). The aim of a testing battery is to encompass a range of tests to ensure that all athlete attributes (e.g., speed, agility, fitness, strength) are evaluated. Data can then be compared against population-specific reference data, facilitating the interpretation of an athlete's scores. Despite this common approach, there appear to be some key limitations. Reference data are typically presented as the mean of a squad (6, 7), or at best, positional subgroups (e.g., in rugby, this may be forwards and backs; (21, 24, 26)). Furthermore, the presentation of mean data by positional group (i.e., forwards or backs) does not identify specific targets for an individual. For example, within rugby union, specific playing positions (i.e., prop, hooker, second row, flanker, number eight) within a positional group (i.e., forwards), all have differing roles during match play (5); thus it is assumed that their respective physiology would also differ. Presenting data as the mean for a group does not provide a target or benchmark for elite athletes, as often a larger degree of inter-athlete and even intra-positional variability will exist (18). The lack of position-specific data are likely due to challenges recruiting sufficient participant numbers from one positional group to establish an appropriate sample size.

There appears to be little consideration for athletes' or coaches' goals when strength and conditioning data are presented in the literature. Common within the discipline of sport and exercise psychology is performance profiling, which was first introduced by Butler (2-4). Performance profiling stems from personal construct psychology (13-15), which in the broadest sense, is concerned with understanding the ways individuals perceive and behave within the world. Performance profiling encourages researchers and practitioners to regard an individual's perception or meaning of their performance as an essential source of information for identifying and understanding areas requiring improvement (8). Typically, this approach is lacking from the strength and conditioning literature, as even when individual case studies are presented, the goals of the athlete or indeed coach are often not considered (19). The development of performance profiling was to surpass traditional psychometric assessments that impose desirable constructs on an athlete (i.e., questionnaires), allowing participants to be more active in the decision-making or goal setting process (8). Participants would rank the importance of each attribute assessed. Attributes are then multiplied by the ranking score to provide greater context and relative importance within the interpretation (12). This concept would appear advantageous in the development of multidisciplinary support for athletes. Traditionally, a strength and conditioning coach would test an athlete and present data back to the coach or athlete to identify their respective strengths and weaknesses. Collaborative interpretation of the data, as used during performance profiling, would progress interdisciplinary to multidisciplinary practice.

The purpose of this article is to propose a collaborative method of interpreting fitness testing data, in relation to reference data with the addition of an athlete and coaches' ratings of the perceived importance of individual attributes.

METHODS

Approach to the Problem

Data from three academy rugby league players from an English Super League club were used to present this multidisciplinary approach when interpreting fitness testing data. The data were collected at the end of preseason in February 2015. Players were assessed on anthropometric (height, body mass, sum of four site skinfolds) and physical (10 and 20 m sprint, 10 m momentum, vertical jump, Yo-Yo intermittent recovery test level 1 [IRT-1], one repetition max [1-RM] back squat, bench press and prone row) qualities. In collaboration with each player, three experienced rugby coaches then ranked the importance of the tests performed, considering playing position, stage of physical and technical / tactical development, and future goals. Data were then presented in various ways to highlight a novel way of athlete profiling, supporting the interpretation of the data.

Subjects

Three male professional academy rugby league players were included in the study. Player one was a positional prop (age 17 years; height 186.5 cm; body mass 93.2 kg). Player two was a positional hooker (age 18 years; height 173.2 cm; body mass 89.0 kg) and Player three was a positional winger (age 18 years; height 180.5 cm; body mass 84.1 kg). Players were involved in a professional rugby league academy, undertaking 3-4 gym-based sessions and 2-3 field-based sessions per week during preseason. All experimental procedures were approved by the institutional ethics committee with assent and parental consent provided along with permission from the rugby league club.

Procedures

The data were obtained from fitness testing sessions completed across two testing sessions, as previously described by Till et al., (26). The procedures were replicated to allow a comparison with the reference data previously published (26). All testing was undertaken by the lead researcher, and consisted of a standardised warm up including jogging, dynamic movements and stretches prior to testing, followed by full instruction and demonstrations of the assessments. The first testing session assessed speed (10 and 20 m sprint) and endurance (Yo-Yo IRT-1) capacity. Three days later, the second testing session was undertaken and incorporated gym-based testing including anthropometric (height, body mass, sum of four site skinfolds), countermovement jump and 1-RM strength (back squat, bench press, prone row) measures.

Height was measured to the nearest 0.1 cm using a Seca Alpha stand (Seca, Birmingham, UK), and body mass, wearing only shorts, was measured to the nearest 0.1 kg using calibrated Seca Alpha (model 770) scales. Sum of four site skinfolds (biceps, triceps, subscapular, suprailliac) were measured using calibrated skinfold callipers (Harpenden, British Indicators, West Sussex, UK) in accordance to Hawes and Martin (9). A countermovement jump, with both hands positioned on the hips, was used to assess lower body power using a just jump mat (Probotics, Huntsville, AL, USA). Jump height was measured to the nearest 0.1 cm from the highest of three attempts recorded (26). Players were allowed 60 seconds rest between each countermovement jump. Sprint speed was assessed over 10 and 20 m using timing gates (Brower Timing Systems, IR Emit, Draper, UT, USA), as described by Till et al., (26). Players started 0.5 m behind the initial timing gate and were instructed to set off in their own time and run maximally past the 20 m timing gate. Times were recorded to the nearest 0.01 seconds with the quickest of the three times used for the sprint score. To calculate player momentum ($kg \cdot sec^{-1}$), 10 m sprint velocity (distance / sprint time) was multiplied by body mass (kg).

Endurance capacity was assessed via the Yo-Yo IRTL-1. Players completed 20 m shuttles, keeping to a series of beeps, followed by a 10-second rest interval. Running speed increased progressively throughout until the players reached volitional exhaustion or until players missed two beeps, resulting in the test being terminated. $\dot{V}O_2$ was then predicted ($\dot{V}O_2$ ($ml \cdot kg^{-1} \cdot min^{-1}$) = IR1TL-1 distance (m) × 0.0084 + 36.4; (1)) to allow comparisons with reference data (26), although it is accepted that a degree of error exists when predicting $\dot{V}O_2$ *per se* (16). Strength assessment included a 1-RM back squat, bench press, and prone row, exercises with which all players were familiar as they were regularly used as part of their training program. Players performed a warm-up protocol of 8, 5, and 3 repetitions of individually-selected loads before 3 attempts of their 1-RM with 3-minute rest between attempts. For the squat, all players had to squat down until the top of the thigh was parallel with the ground, and then return to a standing position to record a 1RM score (26). For the bench press, athletes lowered the barbell to touch the chest and then pushed the barbell until elbows were locked out (26). For the prone row, the players lay face down on a bench which was determined so players' arms were locked out at the bottom position and then had to pull the barbell towards their chest, touching the bench.

In collaboration with each player, three rugby coaches, who worked with the players 3-4 times per week, ranked; body mass, explosive power (i.e., countermovement jump), acceleration (i.e., 10 m sprint), sprint ability (i.e., 20 m sprint), momentum, fitness (i.e., Yo-Yo test) and strength (i.e., squat, bench press and prone row) from the most (weighting of 7) to least (weighting of 1) important quality for each individual player. Prior to this, an experienced accredited (UKSCA) strength and conditioning coach explained what each test measured (e.g., the physiology), and how this likely translated to rugby *performance*. The rugby coaches did not have any specific education in strength and conditioning or athletic development, therefore the strength and conditioning coach provided examples of rugby specific key performance indicators (i.e., the tackle, successful collision, line bust, finishing a line break [by out running the opposition]) to align the tests to. The aim of this collaborative method was to ensure that the strength and conditioning coach, rugby coach and player were all working on the same goals to develop their rugby performance. The coaches and player reached a consensus for each of these qualities prior to their importance score being used. Coaches valued the input from each player, and understood the importance within the goal setting process. The ranking scores are shown in Table 1.

Statistical Analyses

Data are presented for individual players. Z-scores (statistical measurement of a score's relationship to the mean in relation to the standard deviation (*SD*)) are then presented with 0 representing the mean provided by Till et al. (26). A Z-score of 1 represents a player whose test scores were 1 *SD* above the mean (26), and a Z-score of -1 represents a player whose test scores were 1 *SD* below the mean (26). Modified Z-scores were then calculated to compare the players to benchmark data. The modified Z-score (i.e., 0) was determined as 2 *SD*s (i.e., 98th percentile) above the mean. Thus, when modified Z-scores are presented, a Z-Score of -1 represents a player whose test scores were 1 *SD* away from the benchmark data (mean plus 2 *SD*s; (26)). To incorporate the coach-athlete ranking the modified Z-score was simply multiplied by the coach-athlete ranking.

RESULTS

The following section presents the players data in various ways, to demonstrate the proposed method. Physical profiles of three players, their respective Z-score away from benchmark data (mean plus 2 *SD*s above data from Till et al. (26)), coach-athlete ranking score based on importance and total score (Z-Score away from benchmark data multiplied by coach-athlete ranking score) are shown in Table 1.

Table 1. The physical profiles of three players, presented as Z-Scores away from benchmark data, coach-athlete ranking score based on importance and total score (Z-Score away from bench mark data multiplied by coach-athlete ranking score).

	Reference data (26)		Player 1 (Prop)				Player 2 (Hooker)				Player 3 (Winger)			
	Mean	Benchmark Reference Data	Test Score	Z-Scores away from Benchmark	Coach-Athlete Ranking	Total Score	Test Score	Z-Scores away from Benchmark	Coach-Athlete Ranking	Total Score	Test Score	Z-Scores away from Benchmark	Coach-Athlete Ranking	Total Score
Body Mass (kg)	88.8 ± 9.9	108.6	93	-1.6	7	-11.0	89	-2.0	2	-4.0	84	-2.5	1	-2.5
CMJ (cm)	52.5 ± 5.5	63.5	48.1	-2.8	5	-14.0	50.2	-2.4	3	-7.3	52.2	-2.1	4	-8.2
10 m Sprint (secs)	1.82 ± 0.07	1.68	1.86	-2.6	2	-5.1	1.79	-1.6	6	-9.4	1.76	-1.1	6	-6.9
20 m Sprint (secs)	3.11 ± 0.12	2.87	3.07	-1.7	1	-1.7	3.02	-1.3	1	-1.3	3.00	-1.1	7	-7.6
10m Momentum ($kg\cdot sec^{-1}$)	488 ± 47	582	500	-1.7	6	-10.5	497	-1.8	5	-9.0	477	-2.2	5	-11.2
Est. $\dot{V}O_2$ ($ml\cdot kg\cdot min^{-1}$)	48.5 ± 2.9	54.3	48.0	-2.2	3	-6.5	53.0	-0.4	7	-3.2	52.0	-0.8	2	-1.6
Squat (kg)	138.4 ± 19.6	177.6	155	-1.2	4	-4.6	140	-1.9	4	-7.7	135	-2.2	3	-6.5
Bench (kg)	113.3 ± 16.4	146.1	135	-0.7	4	-2.7	105	-2.5	4	-10.0	105	-2.5	3	-7.5
Prone Row (kg)	97.6 ± 12.4	122.4	105	-1.4	4	-5.6	97.5	-2.0	4	-8.0	85	-3.0	3	-9.0

Benchmark reference data are based on the 98th percentile of data presented by Till et al., (26). CMJ = countermovement jump

For Player one, countermovement jump, 10 m speed and estimated $\dot{V}O_{2max}$ were all below mean reference data. Player two had lower countermovement jump and upper body strength in comparison to mean reference data (26). Player three had lower body mass, 10 m momentum and strength scores in comparison to mean reference data (26).

The coaches ranked body mass, 10 m momentum and countermovement jump as the three most important attributes for Player one, while 20 m speed, 10 m speed and estimated $\dot{V}O_{2max}$ were ranked as the least important. For Player two, estimated $\dot{V}O_{2max}$, 10 m speed and 10 m momentum were ranked as most important, whereas 20 m speed, body mass and countermovement jump were deemed least important. For Player three, 20 m, 10 m speed and 10 m momentum were ranked as the most important, in contrast to body mass, estimated $\dot{V}O_{2max}$ and strength, which were ranked as least important.

Data in comparison to their peers and mean data are shown in Figure 1A. Only data with comparable units (i.e., kg) can be presented, therefore other variables are not depicted. Figure 1B presents all the characteristics for players as Z-scores against mean reference data (26).

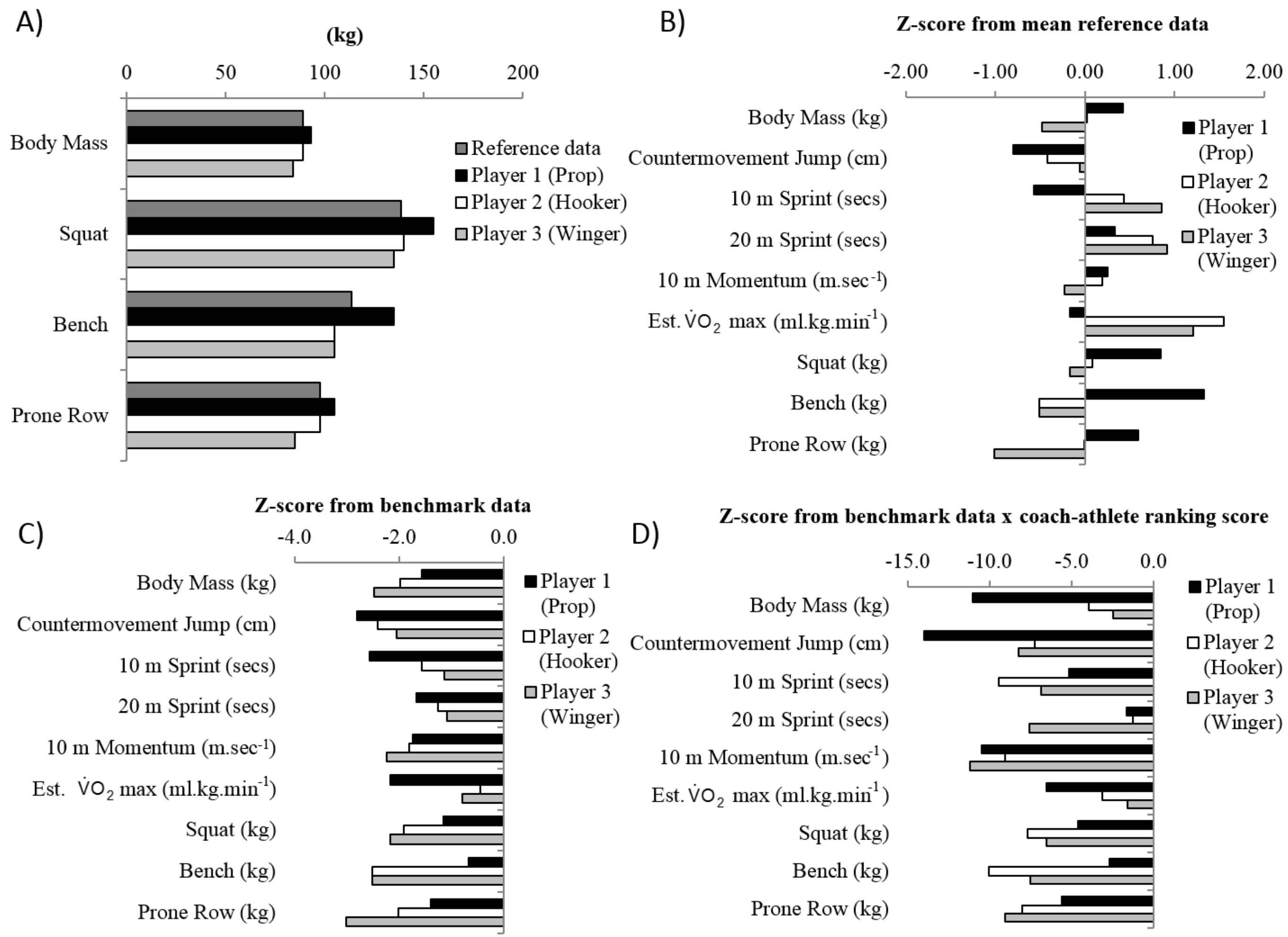

Figure 1. A) Presentation of body mass and strength data for three male academy rugby league players against mean reference data (26). B) Presentation of fitness characteristics for three male academy rugby league players against mean reference data (26). C) Presentation of fitness characteristics for three male academy rugby league players against benchmark mean reference data (26). D) Presentation of fitness characteristics for three academy male rugby league players against benchmark mean reference data (26) multiplied by coach-athlete ranking score.

Figure 1C depicts player characteristics against benchmark (mean plus 2 *SD*s), as opposed to mean reference data (26). When reviewing player characteristics, for example body mass, player three is furthest away from benchmark data, whereas player one is closest. In contrast, for 20 m sprint, Player one is furthest away from benchmark data, whereas player three is closest.

Figure 1D presents player characteristics, incorporating the coach-athlete weighting. The 0.0 is still the benchmark (i.e., mean plus 2 *SD*s; the 98th percentile), although the distance away now considers how the coach-athlete ranked the importance of the characteristics for each player. When reviewing the same example characteristics (i.e., body mass and 20 m sprint), Figure 1D identifies different player weaknesses, for body mass, Player one is furthest away from benchmark data, as opposed to Player three who was further away in Figure 1C. Player three is now closest to the benchmark. This is due to the importance of body mass for Player one and relatively lower importance for Player three. A similar trend is apparent for 20 m sprint, as Player three is now furthest away from benchmark data, as opposed to Player one who was the furthest away in Figure 1C. This is again due to the importance of 20 m speed for Player three and relatively lower importance for Player one.

DISCUSSION

This article considers the importance of coach-athlete ranked player characteristics when presenting athlete profile data. The purpose of athlete profiling is to identify strengths and weaknesses, to assist in the development of player characteristics for performance or development. This report shows that when data are presented against benchmarks, considering the importance of the characteristics when collaboratively ranked by the athlete and coaches (Figure 1D), different athlete weaknesses can be highlighted, as opposed to the presentation of data as absolute values (Figure 1A), against mean data (Figure 1B) or benchmark data on their own (Figure 1C). Reference data presented in the literature is typically representative of various positional playing groups to present data from a large sample. Despite the importance of a large sample size, the application of this type of data are limited for elite athletes.

The limitation of presenting data in absolute units is that it is not possible to detail all of an athlete's physical qualities (due to varying units of measurement such as kg, seconds, cm, etc.). Thus, despite the presentation of an athlete's data against others' or mean data, it does not present all their characteristics, provide a benchmark or target, and may not account for individual goals, attributes or desired characteristics. The use of Z-scores using mean data allows measures with varying units to be presented on the same figure (i.e., Figure 1B), and thus the chance to view all physical attributes for the target athlete. Limitations of this presentation method still exist: it remains a comparison to mean reference data, and does not provide a robust benchmark as it is unlikely that athletes will strive to achieve mean levels of characteristics associated with athletic performance. As such, modifying the Z-score to provide athletes with a benchmark may be a more appropriate method of data presentation (Figure 1C), although a limitation of this current method is that it does not account for individual goals, attributes or desired characteristics. Given the large degree of within- and between-positional differences that exist, the use of mean data, even when modified to provide a benchmark, is questionable for elite athletes. As such, multiplying the data by a collaborative coach-athlete rating (based on a hierarchy of most to least important) provides the athlete with individual, identifiable and accessible traits to develop (Figure 1D). Athletes should, therefore, focus on attributes that are identified as furthest away from their benchmark, and in turn, considered by coaches to be important correlates of peak performance.

PRACTICAL APPLICATIONS

Strength and conditioning coaches should look to present the performance characteristics of athletes against benchmark data, but also collaboratively with a coach and athlete to consider the importance of each characteristic for individuals. In practice this process allows athletes and coaches to specifically focus on individual weaknesses which are identified as being important for an athlete's particular role in their sport or stage of development.

The examples presented from this Case Study show how data presentation may affect the specific goals of players. For example, when observing the Z-score for Player one (prop), countermovement jump and 10 m speed are the only tests that appear below average. Body mass on the other hand appears above average. Given body mass development was the main goal (achieved the highest score for the coach-athlete ranking) for this player, he may have not been aware of this given he was already 'above average'. Therefore when the modified Z-score was multiplied by the weighting factor, it is clear the athlete needs to focus on this attribute. A similar example is presented for Player three (winger), who was below average for body mass, and above average for 20 m speed. When the modified Z-score is multiplied by the coach-athlete ranking weighting factor, 20 m speed is identifiable as an attribute to develop. Focusing on specific attributes as opposed to multiple attributes would likely maximise the intended adaptation by reducing any interference. Again this supports the ability of being able to objectively identify goals from a large fitness testing data set, as shown in this Case Study example.

When between athletes comparisons are made, 20 m speed from this Case Study is also a good example. From the modified Z-score (Figure 1C), the order appears Player three, Player two and then Player one (best to worse). Based on the coach-athlete ranking 20 m speed is low on the priority for Player one, given his playing position. As such, when multiplying the modified Z-score with the coach-athlete ranking, the order appears inverse, as this now considers players goals (Player one, Player two and then Player three; best to worse, Figure 1D).

This article proposes a useful and novel method, based on Z-scores and coach-athlete rating for practitioner to identify a target for individual athletes from a comprehensive testing battery which may produce a large amount of information. The proposed method, with the use of effective and simple spread sheet use can up a time effective way of processing data objectively. Practitioners need to be aware that buy-in from the player and coach is needed for this method to work effectively.

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